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Technical News Bulletin

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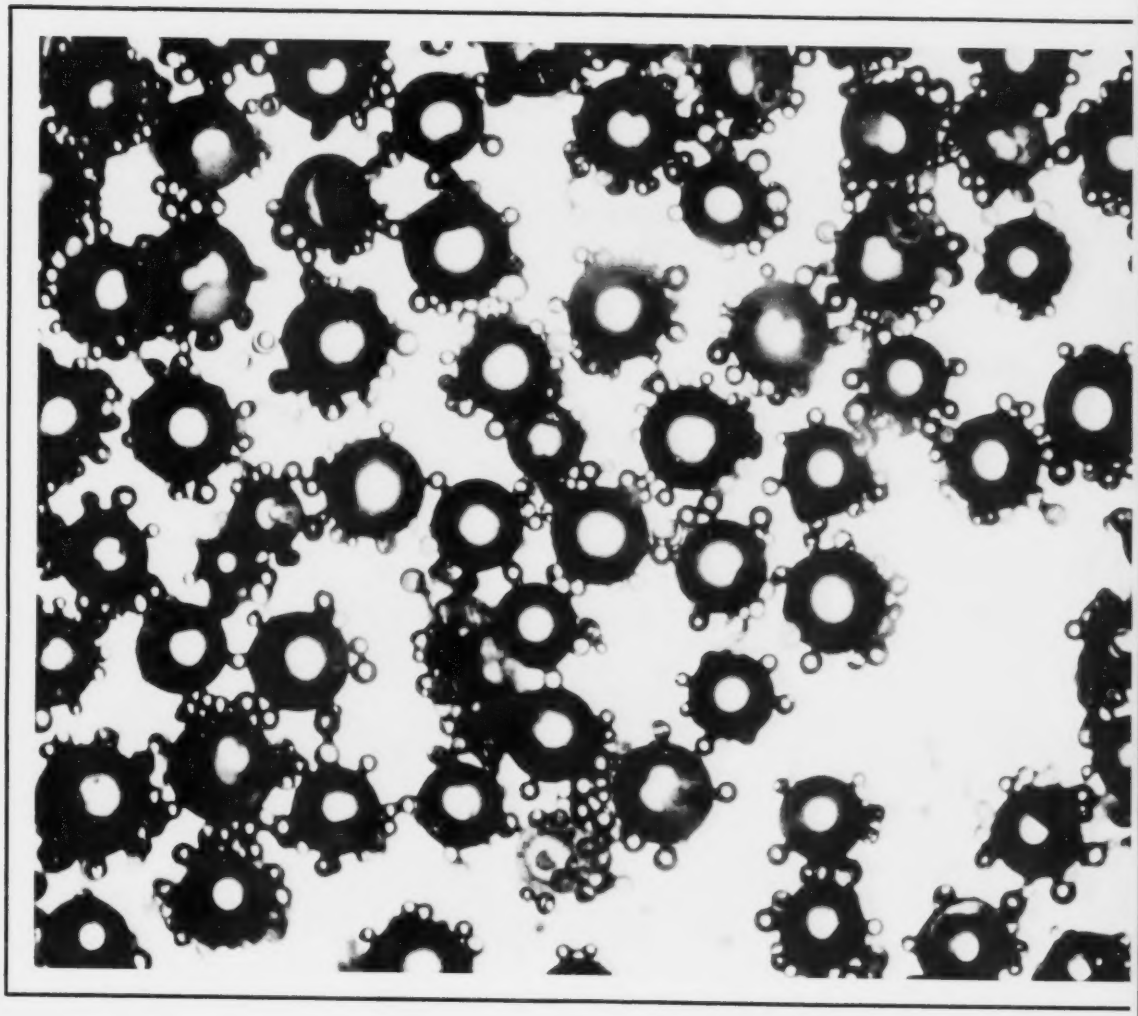

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

U.S. DEPARTMENT OF COMMERCE
John T. Connor, Secretary
NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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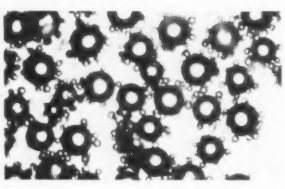


COVER: Photomicrograph of glass spheres for use in an improved dental filling material for anterior teeth. This particular distribution, with about two parts of larger to one part of smaller particles, allows a greater proportion of reinforcing filler and less binding resin. The composite thereby has improved dimensional stability over dental resins currently in use (see p. 62).

New Accelerometer Contributes to Pilot Safety

Developed by Alfred B. Castle, Sr., NBS Institute for Applied Technology

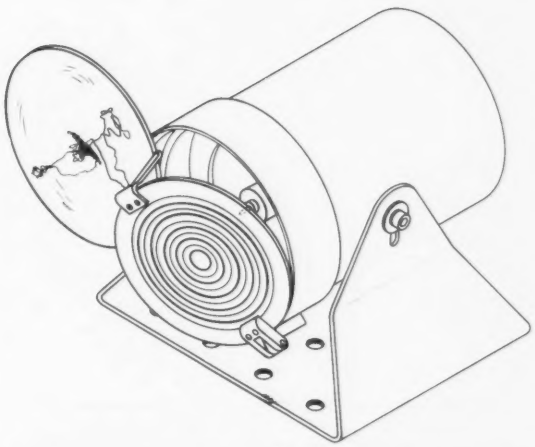
THE BUREAU has developed a mechanical recording accelerometer for the Bureau of Naval Weapons. The device is designed for use in naval aircraft to indicate whether the craft has been subjected to excessive forces when launched by catapult or stopped by arresting gear. It measures forces along two axes directly and records them graphically with high repeatability. Reliable and foolproof, it requires no power, has no connections, and records without any attention during flight.

Naval aircraft launched by catapult and landing on a carrier deck are subjected to acceleration forces that vary with choice of pilot and motion of the ship. Forces exerted when the arresting gear is engaged sometimes damage the airframe or landing gear. An aircraft known to have been subjected to a force of such magnitude must be examined for airworthiness before being used again, but such instances are seldom recognized when they occur.

Conventional instrumentation unfortunately warns of danger only after delays for reduction of data on magnetic tape or for processing film. The NBS accelerometer provides a record that is easily read as soon as the aircraft is secured on deck. It records acceleration as a vector, the form most meaningful in evaluating damage. This measurement could be obtained from conventional uniaxial electrical instruments only by means of several computation steps.

The biaxial accelerometer's simplicity and ability to record the maximum acceleration during an indefinite recording period recommend it for monitoring multiaxial forces on any vehicle, as well as shocks inflicted on delicate instruments. Vehicular applications include monitoring ship's bow acceleration in heavy seas as an indicator of possible hull damage; use in trucks, trailers, and railroad freight cars to warn of possible damage to structure or cargo as a result of excessive loads, bumps, coupling shock, or railroad "humping." Such a device can also be packaged with delicate shipments for use in examining claims for damage in transit. Possible applications in research are for testing the performance of machinery, components, and vehicles; examples are measuring accelerations on an automobile during cornering or accelerations transmitted by an experimental suspension while traversing a "standard bump."

The recording accelerometer was designed to take advantage of the reliability of mechanical instrumentation. It consists of a spring steel wire, securely anchored at one end and bearing at its other end a stylus which presses against a replaceable glass disk. Before use, the disk is removed through a hinged front "window" and sprayed lightly on one side with chalk-type glass cleaner. When the disk is reinserted and the window closed, the stylus bears lightly against the opaque while film with sufficient pressure to press through it.



Accelerometer contains a spring beam carrying a stylus, which traces its movements on an opaque film. Accelerations recorded during flight are seen as traces scribed on the glass plate, shown partially removed. The concentric circles on the hinged windows are the scale of *g*-values.

For use in aircraft, the accelerometer is mounted near the craft's center of gravity with its indicating face including both the vertical and fore–aft axes. The stylus jerks backwards with launching, returns to its 1-*g*-down position when the aircraft attains a fixed speed and climb, and jerks forward when the aircraft is brought to a stop by the carrier's arresting gear. All movements are recorded as lines scribed through the opaque film, visible as black lines. The disk can be retained as a permanent record or used again after a new film is applied.

Values of *g* along the trace are determined by comparison with a scale engraved as concentric circles on the face of the hinged window, with the zero-point at the center. This frame of reference disappears when the disk is removed, but for later inspection it can be replaced by superimposing a similar scale.

The NBS biaxial accelerometer was tested by comparing its indications with those of conventional electronic instrumentation installed in test aircraft. Differences between values obtained by the two methods were less than 10 percent. The high reproducibility of the mechanical measurements was indicated by the similarity of the *g*-patterns for successive flights by the same pilot. These patterns were also distinctively different for different pilots.

reflects new responsibilities

CRPL Reorganization

THE BUREAU'S Central Radio Propagation Laboratory (CRPL) at Boulder, Colo., has been reorganized to meet new space-age responsibilities, according to C. Gordon Little, Director of the Laboratory. The restructuring will result in a new definition of responsibilities for each of four divisions in the Laboratory.

The new organizational structure will enable CRPL to respond more effectively to its assignment of the Department of Commerce responsibility for research and services in the monitoring and prediction of disturbances in the earth's space environment, and at the same time to continue to provide and extend its traditional services to the Nation's telecommunication groups. CRPL is already involved in space weather predictions for manned and unmanned exploration of the earth's atmosphere, and for radio communication purposes. These predictions are primarily concerned with the effect of solar events upon the upper atmosphere and near space.

New responsibilities in support of telecommunications have resulted from an evaluation, by the Interdepartmental Committee for Atmospheric Sciences, of the atmospheric research required to facilitate electromagnetic telecommunications. A need for increased environmental research was disclosed. The committee's recommendations are reflected in the new CRPL organization. Recommendations by the National Academy of Sciences–National Research Council Advisory Committee and the Federal Council for Science and Technology also influenced the change.

Dominant in the recommendations made by these groups is the need to increase emphasis on electromagnetic communication at the higher radio frequencies and at the infrared and visible frequencies. These frequencies contain the vast majority of the frequencies usable for telecommunication. Present knowledge of how to use these higher frequencies is extremely limited and must be improved if the electromagnetic spectrum is to be properly utilized.

Responsibility for the space-related programs will be assigned to two new divisions: the Space Environment Forecasting Division, headed by Robert W. Knecht; and the Aeronomy Division, under Ernest K. Smith. The telecommunications-oriented programs of CRPL will be grouped into an Ionospheric Telecommunications Division, Richard C. Kirby, Chief, and a Tropospheric Telecommunications Division headed by Robert S. Kirby.

A new responsibility in CRPL has been given to Jack W. Herbstreit as Chief of the Program Planning and Liaison Office. He will continue to serve as Deputy Director of the Laboratory. Kenneth A. Norton, consultant on systems analysis, and Roger M. Gallet, consultant on radio physics, will serve as consultants to this office and to CRPL at large.

James R. Wait continues as Senior Research Fellow under the new organization and will also continue to serve as coordinator for all of NBS Boulder Laboratories' international programs supported by counterpart funds. Administrative services will be directed by Robert T. Frost.

The Central Radio Propagation Laboratory is one of four Institutes that make up the National Bureau of Standards. It is the central agency of the Federal Government for obtaining and disseminating information on the propagation of electromagnetic waves, on the electromagnetic properties of man's environment, on the nature of electromagnetic noise and interference,

C. Gordon Little (*left*), Director of CRPL, and A. V. Astin, NBS Director, discuss research programs in the field of aeronomy.

Aerial view of the Bureau's Boulder (Colo.) Laboratories. The main Radio Building (*foreground*) is headquarters for newly reorganized CRPL. Part of the main building also houses the Radio Standards Laboratory. Building in the background is the Cryogenics Laboratory.

and on methods for the more efficient use of the electromagnetic spectrum for telecommunication purposes. The Laboratory serves as the primary Federal agency for basic and applied research in these fields; acts as the central repository for data, reports, and information in these fields; and furnishes advisory and consultative services to industry and to other governmental and nongovernmental organizations.

The Central Radio Propagation Laboratory also provides scientific liaison with other countries to advance knowledge in areas of its responsibilities. As its part in the programs of the International Years of the Quiet Sun it issues predictions of electromagnetic wave propagation conditions and warnings of disturbances.

As the central Federal organization for conduct of propagation research and services in support of the $20-billion-per-year telecommunications industry, CRPL must conduct a broad program of investigation. A brief survey of the CPRL research program includes some of the following activities:

The experiment aboard the *Topsi* satellite launched by NASA in August 1964 was conceived by and is the responsibility of CRPL scientists and engineers. The measurements, made by the satellite from a height of 600 mi above the earth, are providing much new information about the upper, ionized regions of the atmosphere that make possible long-distance radio communication. CRPL scientists have made new discoveries concerning changes and irregularities in this environment which affect high-frequency radio transmissions. This knowledge will benefit users of long-distant ionospheric telecommunications, and especially defense activities operating worldwide communication networks.

Programs are under way to predict for the telecommunications engineer the quality of signal he can expect to receive from a wave which has traveled through the atmosphere under varied conditions. For example, the radio engineer wants to know what is necessary for intelligible and dependable reception of a signal transmitted across mountains or through jungles, at all times of the day, and over a wide range of heights, distances, and climates. CRPL studies provide the radio engineer with the information he needs to improve his transmissions. Knowledge of atmospheric effects and how to overcome, avoid, or exploit them permits the design of improved transmitters, antennas, and receiving systems and the introduction of such new capabilities as over-the-horizon radar.

CRPL is undertaking an increasing role in the detection and prediction of natural and manmade disturbances to long-range communication. For example, if a solar flare occurs, will radio transmissions be affected and if so, to what extent? What alternatives are available to avoid a radio "blackout"? Will the earth's environment in space be affected by a solar proton event and will the associated radiation be a hazard to astronauts in space vehicles? How can a clandestine nuclear explosion above the earth's surface be detected? CRPL research in space environment monitoring and forecasting is designed to support the telecommunication needs of industry and government as well as the man-in-space program and the policing of the test ban.

The CRPL staff not only performs the above research and service but plays a continuing and broad advisory role in national and international telecommunication activities. The latter includes participation in the Interagency Radio Advisory Committee (IRAC) and the Consultative Committee on International Radio (CCIR), both committees concerned with radio frequency utilization and allocation.

Precision Detector for Complex Insertion-Ratio-Measuring System

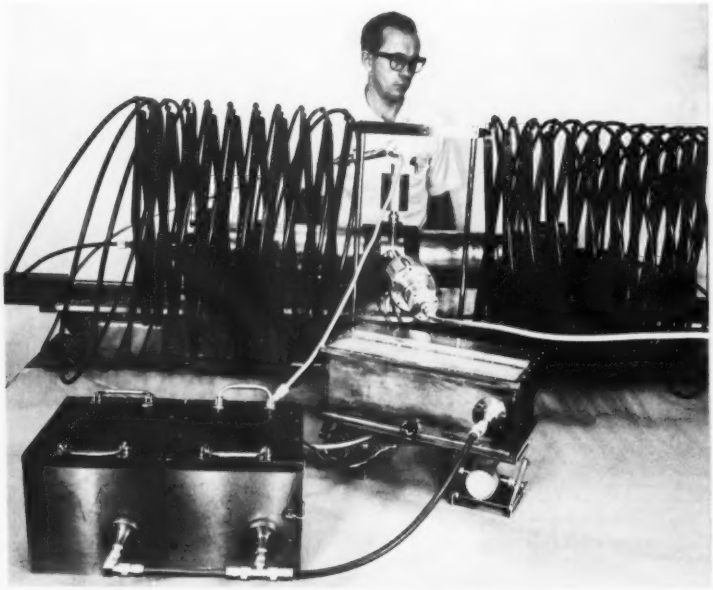
Developed by C. M. Allred and R. A. Lawton, NBS Institute for Basic Standards

A SPECIAL detector [1] has been developed for incorporation into two of the main NBS attenuation-measurement systems to improve the sensitivity and accuracy of the Bureau's standards and its measuring devices. The detector has a sensitivity of 36 picovolts (36×10^{-12} V). This value, obtained with a 30-sec integration time, was only 17 percent greater than the theoretically possible value. The detector is an outgrowth of a continuing Radio Standards Laboratory research program which is seeking accuracies in the order of 0.0001 dB, as well as a detector which will not be a degrading factor in the measurement.

The detector consists of a 30-MHz radiofrequency amplifier and two correlators or multipliers. The rf amplifier is made up of a preamplifier with an input impedance of 17 ohms and a noise figure of 2 dB. The preamplifier is followed in the circuit by a bandpass filter with a center frequency of 30.0 MHz and a 3-dB bandwidth of 210 KHz, which determines the bandwidth of the entire rf amplifier. Following the filter is a post-amplifier with a nominal output impedance of 50 ohms. The overall gain of the rf amplifier may be varied from 128 to 27 dB.

Basic Aspects of the Systems

In the first of the two main attenuation-measurement systems, a three-channel system, the two standard attenuators are waveguide-below-cutoff (or piston) attenuators operating in the TE_{11} mode and arranged so that their outputs are out of time phase by 90 deg. The vector sum of these two attenuators is a vector lying within a 90-deg sector, and it can null any voltage in an opposite quadrant. By rotation of the pickup coils of the two standard attenuators, their outputs may be shifted 180 deg, and hence a voltage lying in any quadrant may be nulled. The desired insertion ratio of the unknown network is obtained from the two sets of readings which are required from the two standard attenuators to produce a null at the detector both before and after inserting the network. The junction is a



R. A. Lawton adjusts the complex insertion-ratio-measuring system.

special unit [2] which isolates the signals from the three channels and also presents matched impedance to the three channels.

In the second attenuation-measurement system,[3] a two-channel system employing a standard attenuator and a standard phase shifter, the two standards are adjusted for null condition, as indicated by the detector, before and after insertion of the network. The change in the phase standard gives the insertion phase angle of the network, and the change in the attenuator provides the insertion loss of the unknown. The unknown network may also be inserted in the attenuator channel instead of the phase standard channel. The junction plays the same role as before.

The detector for such systems should be a stable, low-noise unit which provides the information required by the operator or servosystem to move each standard attenuator independently toward the null condition. That is, the detector indicates for each standard independently whether the attenuation should be increased or decreased and when zero output is obtained.

Performance

Performance tests indicate that this detection system should significantly aid in the development of certain insertion-ratio-measuring systems by providing greatly increased range, convenience, and accuracy.

Actual tests were made on the first attenuation-measurement system described above. A test was made of the response of one of the correlators to an input signal of constant amplitude with phase varied by means of a line stretcher. The result closely follows a cosine curve, indicating that the operation is essentially correct.

As a measure of the independence of the correlators to orthogonal or quadrature signals, it was found possible to have a ratio of 200 between the quadrature signals and the in-phase signals before a significant response was noted due to the quadrature signal.

The sensitivity of the system, for an integration time of 30 sec, was found experimentally by determining the amplitude of the signal necessary to give a mean output deflection just equal to the rms value of the fluctuations of the output indicator. The value of this signal was found to be 36 pV rms. The theoretical value is 17 percent lower than this value. The agreement is considered satisfactory, however, in view of the nature of the measurement, the uncertainties in the values of various quantities such as noise figure, absolute signal level, and imperfections in the integrator, together with the instabilities or drift in the d-c output of the correlators with no noise present. This drift was of the order of the minimum detectable signal during the time of measurement and, of course, helps to increase the effective noise level. Plans have been made to decrease the effect of the drift by increasing the rf gain and decreasing the bandwidth.

The insertion-ratio-measuring device that was used is still under development. There were indications that leakage signals were present that produced a net indicator deflection of the order of the magnitude of the minimum detectable signal. The mean deflection due to leakage was balanced out. Various tests were then conducted to ascertain if the leakage varied during the operations necessary to measure the minimum detectable signal. The indications were that the "balanced mean" remained constant and was equal to zero.

[1] Precision detector for complex insertion ratio measuring systems, *by C. M. Allred and R. A. Lawton, IEEEE Trans. Instr. Meas.* **IM–13,** *Nos. 2 & 3 (June–Sept. 1964), pp. 76–81.*

[2] A multiple isolated-input network with common output, *by C. M. Allred and C. C. Cook, J. Res. NBS* **64C** *(Eng. & Instr.) (July–Sept. 1960).*

[3] A precision R. F. attenuation calibration system, *by C. M. Allred and C. C. Cook, IRE Trans. Instr.* **I–9,** *No. 2 (Sept. 1960).*

NBS Revises Calibration Fees

The Bureau is revising the fees charged for calibration and test services provided to commerce and industry and to other Government agencies. Reflecting cost increases over the last several years, most of the fees are being increased by various amounts, with an overall average of about 30 percent.

The new fees for calibrations and tests are being published in the *Federal Register* as soon as they are established by the Bureau laboratories carrying out the work. Those for the Heat division were published Dec. 29, 1964, and those for the Radiation Physics Division on Jan. 8, 1965. Revised fees for the Electricity, Metallurgy, and Metrology divisions will appear shortly. New calibration and test fees will also be published in collected form in a revised edition of Calibration and Test Services of the National Bureau of Standards (NBS Misc. Publ. 250), which will outline in detail the services and the procedures for obtaining them. When completed, Misc. Publ. 250 will be available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

Correction

An error has been found in the list of physical constants recommended by the National Academy of Sciences-National Research Council (NBS Tech. News Bull. **47,** 175, October 1963). The numerical value of the first radiation constant ($2\pi hc^2$) was erroneously given as 3.7405; the correct value is 3.7415.

dedication of **CLE**

Development of the Clearinghouse for Federal Scientific and Technical Information was endorsed in February 1964 by the Federal Council for Science and Technology, an advisory body to the President. The Council specifically called for the Clearinghouse to serve as the single agency through which unclassified technical reports and translations generated by all Government agencies are uniformly indexed and made available to the public: to provide information on Federal research in progress; and to operate a referral service to sources of specialized technical expertise in the Government.

In addition to providing research information to industry, the Clearinghouse—which is a part of the NBS Institute for Applied Technology—is designed to reduce duplication in both industry and Government in research and information processing. According to the Institute head, Donald A. Schon, savings to the Government of about $500,000 will be realized during the first year of operation as a result of reducing duplication of document processing and distribution within the Government.

A major step in this direction was a recent agreement betwen the Department of Commerce and the Department of Defense whereby the Clearinghouse assumed the task of processing all unclassified/unlimited DoD research reports, as well as reproduction and distribution of these documents to both the public and DoD agencies and contractors.

Senator John L. McClellan of Arkansas, Secretary of Commerce John T. Connor, and Assistant Secretary of Commerce J. Herbert Hollomon joined NBS Director A. V. Astin in dedicating the Bureau's newly established Clearinghouse for Federal Scientific and Technical Information on January 27.

Dr. Astin welcomed 200 guests and introduced Donald A. Schon, Director of the Bureau's Institute for Applied Technology, who described the Clearinghouse operations and future programs. The Clearinghouse, which incorporates the document distribution program of the Office of Technical Services, is located in Springfield, Va.

Secretary Connor called the establishment of the Clearinghouse in the Department "highly appropriate," pointing out that

To an increasing extent, our national economy is science-based. The thrust of innovation which spurs the growth of our industry and commerce comes largely from the laboratory. . . .

The Department of Commerce has recognized this technological challenge. And the National Bureau of Standards has long served the nation in this regard. It has been a focal point for promoting the application of the physical and engineering sciences in industry. And in the future, its role will be more and more critical for the country's economic well-being.

The establishment of this Clearinghouse reflects the Department's lively awareness and concern with these technological challenges. . . . It will help us use our existing national scientific capability more fully. It will help us improve the profitability of our national research investment. And it will do this for both government and private enterprise.

The Secretary reminded visitors representing Congress, the diplomatic community, Government agencies, and business that Senator McClellan

has been especially concerned with the impact of science and technology on our national development. As Chairman of the Senate Committee on Government Operations, he has initiated many hearings and studies on this subject. . . .

At least as far back as 1958, Senator McClellan advocated a clearinghouse for Federally generated scientific information.

EARINGHOUSE for Federal Scientific & Technical Information

Center: **Secretary of Commerce John T. Connor addresses guests attending dedication of the Clearinghouse.** *Upper left:* **Clearinghouse building, located at Springfield, Va.** *Lower left:* **Senator John L. McClellan and Secretary Connor examine output of literature search performance by remote contact with Defense Document Center's Univac computer.** *Right:* **Machine used for rapid reproduction of microfiches (documents in microfilm format).** *Background:* **Part of the Clearinghouse's document collection.**

Secretary Connor told the audience that the Senator was "instrumental in the creation of this center."

Senator McClellan spoke of the *great promise for increased efficiency and economy by the elimination of duplication in an important area of Government functions* in the establishment of the Clearinghouse. *These are goals worthy of our constant pursuit and effort,* he said.

If efficiently distributed and used, federally developed technical information can help our businesses, small and large, in the development of new products and processes. So used, it can create new industries and employment, provide new markets and increase our rate of economic growth.

To assure the maximum public benefit from the use of Federal funds for science and technology, the Government has an obligation to see that the resulting information is made readily available. This requires rapid and efficient collection, organization, and dissemination of such information.

The task of searching for information of this kind has been a great and at times an almost insurmountable barrier to industrial innovation and progress. I am confident that the Clearinghouse we are dedicating today is a major step in meeting this problem.

The Senator emphasized that the tremendous increase in Government-supported research in the last ten years has made the collection and distribution of technical information a more difficult and critical problem for both Congress and the Executive Branch. *It is gratifying,* the Senator continued, *to see those Executive Departments heavily involved in our national research programs take the necessary action to provide a single point of contact—this Clearinghouse—for industry and the technical community for information about government-sponsored technical work.*

When the Clearinghouse is fully functioning, it should be possible for any businessman, scientist, or engineer in the country to obtain information on any technical subject with one call on the Clearinghouse, whether the information originated in NASA, Atomic Energy Commission, the Department of Defense, or any other agency.

I am also impressed by the Clearinghouse efforts to select from the vast amount of incoming information those documents of special interest to a given industry and then to apprise the companies of that industry of the availability of such material.

This should bring valuable information to businesses who are not now utilizing government technical data, and it will also prevent businesses from overlooking the availability of these particularly important documents . . . .

The task facing the Clearinghouse will provide great challenge to the management and staff for many years to come, Senator McClellan concluded. *I know that you will accept that challenge in the interest of the scientific, industrial, and economic growth of our country. And, in meeting that challenge, you will have the added incentive of promoting efficiency and economy in Government.*

The next issue of the *Technical News Bulletin* will contain an article on the operation and services of the Clearinghouse.

improved

ESTHETIC DENTAL FILLING

composite

TEETH filled with unreinforced resins currently in use often continue to decay after the filling is inserted—a situation traced to the instability of bonding between the filling and the tooth. A reinforced resin composite which may help to eliminate this problem has been developed [1] in the Bureau's Dental Research Laboratory. The work is part of a long-range project designed to provide the public with a permanent, direct filling material for anterior teeth.

Investigation by Dr. R. L. Bowen, research associate of the American Dental Association at NBS, resulted in a technique which allows an increased concentration of silica-powder particles in the filling, thus permitting a greater silica-to-resin ratio. The resin is used simply to bind the filler particles together; it is therefore desirable to maximize this ratio while maintaining standards of quality and durability in the composite. The enhanced packing density allows the filling material to match the missing tooth structure more closely.

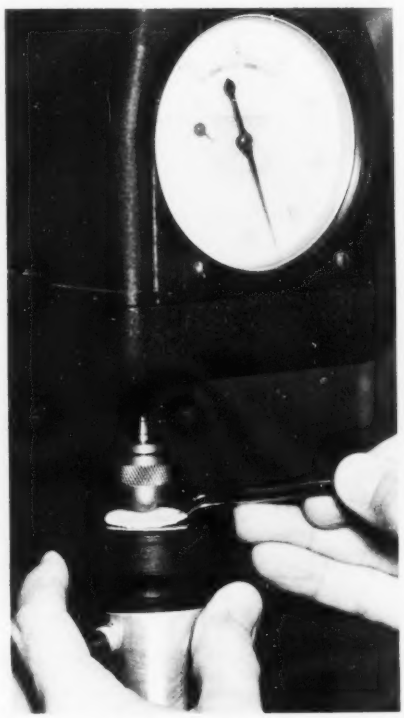
Silica-glass powders [2] were used in this work because of their low coefficients of thermal expansion. The increased proportion of powder thus produced a composite with a lower thermal expansion, which should significantly increase the stability of the tooth-to-filling bond and therefore reduce the possibility of further decay.

Application of theories concerned with the packing of solid particles in air indicated that the packing density of the filler could be increased if its component particles were spherical in shape and of a particular size distribution. Various distributions were tested; the optimum was about two parts of coarser particles and one part of finer particles. High diameter ratios (over 10:1) give best packing, but the unavailability of very fine glass spheres limited the range that was investigated.

Eight reinforced resins were tested and compared with an unreinforced resin. The most successful of the materials investigated was a composite prepared with 87 percent reinforcing powder consisting of soda-lime-silica glass spheres. The coarse particles, averaging 130 microns in diameter, made up 70 percent of the volume while the medium spheres, averaging 30 microns in diameter, comprised the remaining 30 percent of the volume. Such a bimodal distribution of spherical particles required only 13 percent resin as a binder.

In most instances the properties of the reinforced composites compared favorably with those of unreinforced materials. Hardening times and opacity values were nearly equal. The reinforced material exhibited a greater compressive strength (by 50 percent) and stiffness, while the unreinforced material showed slightly higher tensile and shear strengths. The coefficient of thermal expansion was the most obvious improvement; it varied appreciably with changes in particle size and shape but decreased by over a factor of 5 in the best case.

Qualitatively, the surface texture of the composite improved as the content of the smaller particles increased. There was, however, some evidence of white "streaking" due to polymerization shrinkage of the



A superficial hardness tester is used to measure a reinforced resin for its resistance to indentation.

Dr. R. L. Bowen examines a model of anterior teeth with the clinical microscope. Reinforced resin composites are placed in a patient's teeth and models are then made so that these materials may be compared over a period of years with others materials placed in adjacent teeth.

methylmethacrylate monomer used in this study. The handling properties of these materials indicated that, for direct filling composites, a monomer that has relatively low volatility and polymerization shrinkage must be used. Optimum texture and strength require the use of very fine particles, but the limits of fineness have yet to be determined.

Future work will utilize improved monomers, will determine the feasibility of preparing and using spheroidal particles of vitreous silica and special glasses, and will attempt to determine optimum particle sizes, which should be smaller than those used in the present study.

[1] *For details see* Progress report on effects of particle shape and size distribution in a reinforced polymer, *by R. L. Bowen, J. Am. Dental Assoc.* **69**, *481 (1964).*

[2] *There are indications that the use of an intermittent grading of fused silica spheres would be preferable for this work, but spherical fused silica particles were not available at the time of this investigation.*

Standby Antenna for WWVB and WWVL

NEW STANDBY antenna and transmitter facilities for NBS radio stations WWVB and WWVL at Ft. Collins, Colo., have been constructed and will soon be put into operation.

The standby system, an NBS project supported by other agencies, is an essential part of the Ft. Collins operation which will permit either the WWVB or WWVL main antenna to be shut down for maintenance or modification without depriving users of the 24-hr services of the two stations. When not employed in its standby role, the new system will be used in numerous research projects designed to provide improved services.

WWVB and WWVL are the Bureau's low-frequency and very-low-frequency stations which broadcast standard frequency and time information to industrial and university standards laboratories, earth and space telecommunications agencies, the armed forces, and thousands of other users across the Nation. WWVL also broadcasts the signals used to control the frequency and time at the NBS high-frequency (short-wave) stations, WWV and WWVH.

The new mast for the standby antenna was begun soon after WWVB and WWVL were dedicated in August 1963; it is a guyed steel tower 470 feet (143 m) in height, the tallest mast in the antenna complex. Ten-inch-diameter antenna cages are suspended between it and two existing 400-feet (121-m) masts to form a triangular array. The helix house below contains tuning apparatus for either WWVB or WWVL, and a standby transmitter for each station is being obtained.

The new facilities are not capable of amplitude modulation, but the coverage will be essentially that of the regular broadcasts and users will not suffer a degradation in service. The broadcasts from the standby system may differ from the regular broadcasts by as much as one microsecond because of antenna location.

The new system was first used November 9 to 13, when the regular WWVB antenna was lowered for modifications to make possible higher power transmissions.

Radiographic Film Sensitivity Increased

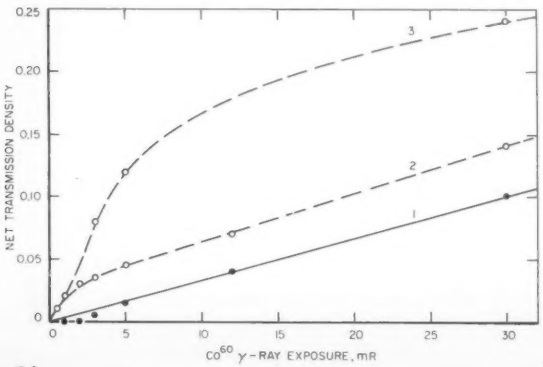
Study by W. L. McLaughlin, NBS Institute for Basic Standards

THE COMBINATION of post-exposure to visible light and special development techniques, each of which contributes about equally, can increase the sensitivity of some commercial radiographic films used for personnel dosimetry by about a factor of 6.[1] These findings, made under Atomic Energy Commission sponsorship, permit the photographic determination of x- and gamma-ray exposures as low as 2.5 mR with precisions comparable to those attained at 15 mR when using conventional procedures. The best combination of treatments with the particular films investigated consists in post-exposure to 580 or 620 mμ light, doubling the normal 5-min development time, and adding a small amount of sodium thiosulfate to the developer.

It has been known for some time that post-exposure of film may produce more additional image in the already exposed emulsion than in the unexposed emulsion.[2] However, post-exposure after an ionizing exposure does not always lead to reinforcement of the original image. In fact, certain exposure combinations can lead to an actual decrease in the density of the original exposure. The Institute's investigation has shown that the type of film, the relative amounts and rate of energy absorbed during the two exposures, the wavelength of the second exposure, and the degree of localization of the development determined the effectiveness of a particular exposure sequence.

Three commercial types of double-coated radiographic films were used in this study. A small cobalt 60 source provided most of the gamma-ray exposures; larger and smaller Co^{60} sources were used to study rate dependence, and a cesium 137 gamma-ray source plus heavily filtered x rays were used to study energy dependence. Wolfram lamps in combination with various glass filters provided the desired optical or near-infrared wavelengths.

A large number of tests using gamma-ray exposures, exposures to light of different wavelengths, and combinations of the two, showed that with two of the films exposure first to gamma rays and then to 580 or 620 mμ light gave a higher net density than that resulting from exposure to gamma rays alone. With the third type of film relatively little enhancement resulted from post-exposure at any wavelength. The use of 770-mμ light gave first a positive and then a negative effect, depending on the amount of gamma-ray exposure, while 720-mμ light produced a negative effect at all exposures. In general, the effects of post-exposure were more pronounced at lower densities.



Curve 1 represents cobalt 60 x-ray response of a sensitive commercial radiographic emulsion, with no post-exposure and normal development; curve 2, with 580 mμ post-exposure and normal development; and curve 3, with 580 mμ post-exposure, doubled development time, and 0.5 g/l sodium thiosulfate added to developer.

Further increase in the sensitivity of the films was sought through various changes in the developing procedure. Chemicals such as alkaline salts to increase the *p*H, organic acids as gelatine denaturing agents, and thiosulfates and thiocyanates as silver halide solvents were added to the developer, and the development time was increased. As already mentioned, the addition of a small amount of sodium thiosulfate (no more than 1.5 g/l was used in this work) to the developer, and the extension of development time from 5 to 10 min, gave about a threefold increase in sensitivity of the post-exposure film.

Experiments were conducted in which many films were exposed to either 3- or 20-mR doses, and then either (1) processed regularly, (2) post-exposed and processed regularly, or (3) post-exposed and intensely processed. The post-exposure and intense processing sequence gave a far better precision at the 3-mR dose. At 3 mR, the regular procedure gave a standard deviation of ±1.5, post-exposure gave a value of ±0.8, and post-exposure plus special development gave ±0.2. At 20 mR there is no large difference, indicating the special treatments are most useful at lower exposures.

No dependence on exposure rate over the range 0.4 to 6000 mR/hr was noted with the enhancement procedures, but a decrease in the difference in response between 25- and 40-keV x rays was noted when sodium thiosulfate was added to the developer.

The effects of delay between initial and post-exposure and between post-exposure and development were investigated. In the case of net density (difference in density between film exposed to ionizing radiation and light, and film exposed to light only), no change in response was found with delays of 0.5 to 200 hr between exposures or between exposure and development, except with one film when intensely developed. The absolute density, however, generally decreased with any delay between exposures, and showed variable changes, depending on the film, with delays between exposure and development.

[1] *See* Latensification in radiographic emulsions, *W. L. McLaughlin, J. Photo Sci. (1965).*

[2] *H. Luppo-Cramer,* Ausfuhrliches Handbuch der Photographie, *II (1), 3d ed., ed. J. M. Eder and H. Luppo-Cramer, Verlag von Wilhelm Knapp, Halle (1927).*

STANDARD MATERIALS

TO MEET demands for standards in new or expanding fields of technology, the Bureau is working on the development of about 50 new standard reference materials and has on hand requests for the preparation of many others. Several new standards have been announced recently.

New Standards

Low-Alloy Steel Standards.—Four new low-alloy steel standards, now available for use in x-ray spectrochemical analysis, have the same compositions as previously issued optical emission standards, but are in a different size suitable for x-ray analysis. The standards are NBS Nos. D803a, acid open hearth (0.06 percent carbon); D805a, medium manganese; D807a, chromium-vanadium; and D809b, nickel. These low-alloy steels are used most often where mechanical, structural, or corrosion-resistance properties better than those of plain-carbon steel are required.

Another new x-ray spectrochemical standard is NBS No. D820a, ingot iron, which is used for quality control during production of this basic ingredient of steel. Ingot iron has been used as melting stock to produce most of the NBS iron-base standards.

Stainless Steel Standards.—Industry uses stainless steel for a myriad of industrial and commercial purposes because of its corrosion resistance, strength, and lasting beauty. To meet industry's need for more stainless steel standards, the Bureau has prepared four new standard materials of the 18 Cr–8 Ni group. These standards (NBS Nos. 1151, 1152, 1153, and 1154) are in disk form, for use primarily in optical emission and x-ray spectrometric analysis (see table 1).

Titanium-Base Alloy Standard.—Light weight, high strength, and high heat resistance make titanium-base alloys particularly useful to the aircraft, missile, and aerospace industries. Because of these characteristics, titanium-base alloys are being used in increasing amounts in other fields. A new standard has been prepared by the Bureau to cover more adequately the range of commercial titanium-base alloys now available and to supplement other NBS titanium-base alloy standards. The new titanium alloy standard (NBS No. 176) has the following provisional certificate of analysis in percentages: Al—5.16, Sr—2.47, Fe—0.07$_0$, C—0.01$_5$, Ni—0.01$_0$, Cu—0.003, Mn—0.0008, and Mo—0.003.

TABLE 1.—*Stainless steel standards for optical emission and x-ray analysis*

Element[3] \ NBS No.[1]	1151[2]	1152	1153[2]	1154
C	0.026	0.163	0.218	0.094
Mn	2.17	1.19	.61	1.74
P	0.011	0.017	.053	0.038
S	.034	.017	.032	.032
Si	.37	.65	.82	1.09
Cu	.25	.50	.26	0.56
Ni	7.03	10.21	12.62	10.25
Cr	22.13	18.49	16.61	19.58
V	0.062	0.044	0.13	0.062
Mo	.76	.36	.21	.46

[1] Size: 1100 series, disks 1¼ inches in diameter and ¾ inch thick.
[2] Fabrication difficulties resulted in a limited supply of this standard.
[3] Other purposely added elements having useful concentration ranges include: Titanium, niobium, tantalum, aluminum, zirconium, cobalt, tin, lead, arsenic, boron, and nitrogen. Some of these for NBS Nos. 1152 and 1154 may be certified at a later date.

Aluminum Brass Standards.—Aluminum brass standards, previously issued only in chill-cast form, are now available in wrought form. The certificate of analysis of the extruded standards (NBS Nos. 1118, 1119, and 1120) are nearly identical to those of the cast form (see table 2). This material is used to make condensers for marine and shore-based power stations because of its resistance to impingement attack of brackish water and high-velocity salt water. Another benefit is its high resistance to sulfur found in polluted harbor water.

TABLE 2.—*Aluminum brass standards for optical emission and x-ray analysis*

Element \ NBS No.	1118	1119	1120
	%	%	%
Copper	75.1	77.1	80.1
Zinc	21.9	20.5	18.1
Lead	0.02$_3$	0.05$_0$	0.10$_5$
Iron	.06$_3$	.03$_0$	.01$_5$
Aluminum	2.8$_0$	2.1$_4$	1.4$_8$
Antimony	0.010	0.05$_0$	0.10$_0$
Arsenic	.007	.04$_0$	.09$_0$
Phosphorus	.13	.07$_0$	.01$_8$
Silicon	.002$_1$	.001$_5$	.001$_1$

Size and metallurgical condition: 1100 series are wrought samples 1¼ in. in diameter, ¾ in. thick. C1100 series are chill-cast samples 1¼ in. square, ¾ in. thick. Price per sample: $25.00.

STANDARD MATERIALS (Continued)

Renewal Standards

The following renewal standards have been issued to replace out-of-stock standards:

(1) *Titanium-base alloy* No. 173A, which replaces No. 173, has the following provisional certificate of analysis in percentages: Al—6.47, V—4.06, Fe—0.15, Co—0.2_5, N—0.01_8, Si—0.03_7, Cu—0.002, and Mo—0.005.

(2) *Sibley Iron Ore Standard* No. 27e, which replaces Mesabi Iron Ore Standard 27d, has the following provisional certificate of analysis (in percentages): Fe—66.6, SiO_2—3.64, and P—0.042.

(3) *Benzoic Acid Standard* No. 39i, replaces No. 39h for calibrating calorimeters.

(4) *Potassium Hydrogen Phthalate* No. 185d, a pH standard, replaces acid potassium phthalate No. 185c.

(5) *Butyl-Rubber Standard* No. 388a replaces No. 388.

(6) *Barium Cyclohexanebutyrate* No. 1051a, Ba—29.1 percent, replaces No. 1051.

(7) *Calcium 2-Ethylhexanoate* No. 1074, Ca—13.4 percent, replaces calcium cyclohexanebutyrate No. 1054.

(8) *Cobalt Cyclohexanebutyrate* No. 1055a, Co—17.4 and Ni—0.05 percent, replaces No. 1055.

(9) *Nickel Cyclohexanebutyrate* No. 1065a, Ni—16.8 percent, replaces No. 1065.

(10) *Sodium Cyclohexanebutyrate* No. 1069, Na—11.9 percent, replaces No. 1069.

Course in Electromagnetic Propagation

The Central Radio Propagation Laboratory of the Bureau, in conjunction with the University of Colorado, will offer a three-week course in electromagnetic propagation from June 28 to July 16, 1965 at the NBS Boulder, Colorado, Laboratories. The course is designed to acquaint scientists and engineers from universities, industry, and government agencies with recent advances in electromagnetic propagation research and their application to the design and development of telecommunication systems.

Topics to be covered in the course include ray theory and tracing techniques, introduction to mode theory and full wave methods, characteristics of the medium, propagation in the frequency ranges from 10 kHz to above 30 MHz, optical propagation, antenna systems, noise, receiving systems, and modulation. Most of the lecturers for the course are from CRPL, while others are from industry and the University.

The course will be preceded by a two-week preparatory course on the fundamentals of electromagnetic theory, for persons who need refreshing on fundamentals before undertaking the propagation course. The refresher course will be held on the University campus from June 14 to June 25.

The courses are being coordinated by J. W. Herbstreit of CRPL and Dr. S. W. Maley of the Electrical Engineering Department of the University of Colorado. Enrollment will be limited and early application is recommended. Further details and registration forms can be obtained from Dr. Maley at the University of Colorado, Boulder, Colo.

Changes in NBS Radio Broadcasts

WWV and WWVH Time Pulses Retarded

The time signals broadcast by NBS stations WWV (Greenbelt, Md.) and WWVH (Maui, Hawaii) were retarded 0.1 second at 0000 UT on March 1, 1965 (7 p.m. EST of February 28). This follows the announcement by the Bureau International de l'Heure (BIH) of such a retardation to be made by all coordinated stations, due to changes in the speed of the earth's rotation. The last previous adjustment was made on January 1, 1965. No change will be made on April 1 or on May 1.

The time pulses will continue to occur at intervals greater than 1 second by 150 parts in 10^{10}, a frequency offset also coordinated by the BIH.

Tone Transmissions Changed

Station WWV has been transmitting audio tones of 440 and 600 Hz by upper single-sideband modulation on 2.5, 5, 10, 15, and 20 MHz and on double-sideband only for the 25 MHz transmission. Beginning March 1, 1965, at 0000 UT (7 p.m. EST, February 28) these tones were modulated by double-sideband modulation at all carrier frequencies and all single-sideband transmissions were discontinued. These audio tones are now included with the voice announcements, time ticks, code announcements and time code which are transmit- at all frequencies used with double-sideband modulation. This change was made to simplify station operation and because of the results of a recent questionnaire which indicated that few users need the single-sideband feature of the past transmissions.

WWVB Time Pulses Retarded

The time signals broadcast by NBS Station WWVB (Fort Collins, Colo.) will be retarded 0.2 second at 0000 UT April 1, 1965 (7 p.m. EST of March 31). This phase adjustment ensures that these second pulses will remain within about 0.1 second of the UT2 scale. It is made necessary because of changes in the speed of rotation of the earth, with which speed the UT2 scale is associated. There will be no change in the WWVB time pulses on May 1.

NOTE: *For a complete description of the NBS standards broadcast services see* The Standard Frequency and Time Services of the National Bureau of Standards, *NBS Misc. Publ. 236 (1965 Edition).*

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. **49**, No. 3, Mar. 1965. 15 cents. Annual subscription: $1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

CRPL Ionospheric Predictions for June 1965. Three months in advance. Number 27, issued March 1965. 15 cents. Annual subscription: $2.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75; single copies, 70 cents.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75; single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75; single copy, 75 cents.

Section D. Radio Science. Issued monthly. Annual subscription: Domestic, $9; foreign, $11.50; single copy, $1.00.

Current Issues of the Journal of Research

J. Res. NBS **69B** (*Math. and Math. Phys.*), Nos. 1 and 2 (Jan.–June 1965), 75 cents. Revised contents.

Lectures on matroids. W. T. Tutte.
Menger's theorem for matroids. W. T. Tutte.
Single-element extensions of matroids. H. H. Crapo.
Minimum partition of a matroid into independent subsets. J. Edmonds.
Lehman's switching game and a theorem of Tutte and Nash-Williams. J. Edmonds.
On the connection between the properties of oriented linear graphs and analyses of lumped physical systems. H. M. Trent.
Character subgroups of *F*-groups. M. I. Knopp and M. Newman.
A note on multipliers of difference sets. R. A. Brualdi.
Modification of Edmonds' maximum matching algorithm. C. Witzgall and C. T. Zahn, Jr.
On measurable sets and functions. A. J. Goldman.
Characteristic formulation for nonperiodic solutions of Mathieu's equation. T. Tamir and H. C. Wang.
On the surface duality of linear graphs. J. Edmonds.
Maximum matching and a polyhedron with 0,1-vertices. J. Edmonds.

Radio Sci. J. Res. NBS/USNC–URSI, Vol. **69D**, No. 4 (Apr. 1965), $1.00.

Waves in Plasma Papers

Dispersion of waves in a cold magneto-plasma from hydromagnetic to whistler frequencies. H. G. Booker and R. B. Dyce.
Study on the guiding mechanism of whistler radio waves. S. Adachi.
Electromagnetic waves along an infinitely long and thin conducting wire in a magneto-ionic medium. Y. Mushiake.
Use of the phase-integral method to determine the reflection properties of a stratified ionosphere. C. Altman.
E-mode propagation in a plane-stratified plasma. P. Hirsh and J. Shmoys.
Radiation from an infinite axial slot on a circular cylinder clad with magnetoplasma. P. de Marchin and G. Tyras.
Index of refraction surfaces for plasma waves. T. Yeh and M. H. Cohen.
Impedance of a short dipole in a compressible plasma. K. G. Balmain.
Waves circulating around a rigid cylindrical obstacle in a compressible plasma. J. R. Wait.
Wave propagation in a two component warm plasma. S. R. Seshadri.
Harmonic currents excited by an electromagnetic wave in a plasma. L. Wetzel and T. W. Tang.
Excitation of acoustic waves in plasmas. W. A. Saxton.
Wave interaction in oxygen magneto plasmas. K. V. Narasinga Rao.

Regular Contributions

Test of the constancy of the velocity of electromagnetic radiation in high vacuum. P. Beckmann and P. Mandics.
Signal degeneration in laser beams propagated through a turbulent atmosphere. P. Beckmann.
High frequency backscatter from the earth measured at 1000 km altitude. R. C. Chia, A. K. Fung, and R. K. Moore.
Observation of NPG VLF transmissions at Tracy, California during path equinox. G. B. Carpenter and A. L. Whitson.
Small magnetic toroid antenna imbedded in a highly conducting half space. G. R. Swain.

Other NBS Publications

Calibration of liquid-in-glass thermometers, J. F. Swindells, NBS Mono. 90 (Feb. 12, 1965), 25 cents. Supersedes NBS Circ. 600.
Pipe nipples: Brass, copper, steel, and wrought-iron, NBS CS5–65 (Jan. 15, 1965), 10 cents. Supersedes CS5–46.
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Wood awning window units, NBS CS204–64 (Mar. 17, 1964), 10 cents. Supersedes CS204–59.
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